

## ION BOMBARDMENT EXPERIMENTS SUGGESTING AN ORIGIN FOR ORGANIC PARTICLES IN PRE-COMETARY AND COMETARY ICES

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During the Giotto and Vega encounters with Comet Halley both organic particles called CHON (1,2), and energetic ions (3,4) were detected. The acceleration of ions to hundreds of keV in the vicinity of the bow shock and near the nucleus may be a demonstration of a situation occurring in the early solar system (perhaps during the T Tauri stage) that led to the formation of organic particles only now released. Utilizing a Van de Graaff accelerator and a target chamber having cryogenic and mass spectrometer capabilities (5), we have bombarded frozen gases at 10 K with 175 keV protons with the result that fluffy solid material remains after sublimation of the ice (6,7). Initial experiments were carried out with a gas mixture in parts of 170 carbon monoxide, 170 argon, 25 water, 20 nitrogen, and 15 methane formulated to reflect an interstellar composition in experiments involving the freezing out of the products of a plasma (8). The plasma experiments resulted in a varnish-like film residue that exhibited luminescence when excited with ultraviolet radiation, while the ion bombardment created particulate material that was not luminescent.

We have varied the composition of the gas mixture frozen out at 10 K including using carbon dioxide instead of carbon monoxide, and have determined the formation of particulate residues rather than films is more a characteristic of the ion bombardment process than a characteristic of specific ice composition. Quadrupole mass spectroscopy during 175 keV proton bombardment (as molecular hydrogen ions accelerated with a potential of 350 keV) of carbon monoxide, argon, and water ice indicates formation of species at  $m/q$  peaks 29, 30, 32, and 44 suggestive of formyl radical, formaldehyde, methanol, and carbon dioxide (Fig. 1). The infrared spectrum of a fluffy residue prepared from (in parts) 170 carbon monoxide, 25 water, 20 nitrogen, and 15 methane is shown with that of material evaporated from the Orgueil acid insoluble residue during rapid heating in vacuum to 500 C (Fig. 2). The fluffy residue can be imaged by SEM with 1.1 keV electrons without application of a conductive coating, indicating it may not be necessary to coat samples while using a spacecraft SEM avoiding an obvious complication (6).

The formation of particulate material that can be easily broken into fragments is of interest as a laboratory analogue for CHON (1,2). During the T Tauri stage of the sun when the solar wind mass flow could have been 7 to 8 orders of magnitude of its present value, considerable shock activity would have been present with ions accelerated in the shock environment as found for Comet Halley (3,4), the earth's bow shock, and interplanetary shocks. Ice grains and "chunks" (up to several centimeters in size) bombarded by these moderate energy ions (100 keV) would then have particulates formed

within. Aggregation of the bombarded ice grains and "chunks" into a cometary nucleus results in particulates being distributed throughout. Subsequent bombardment of the nucleus surface by shock accelerated ions would yield an enhanced surface layer of dust. The process could also take place at the surface of icy satellites. T. J. Wdowiak acknowledges NASA grant NAGW-749.

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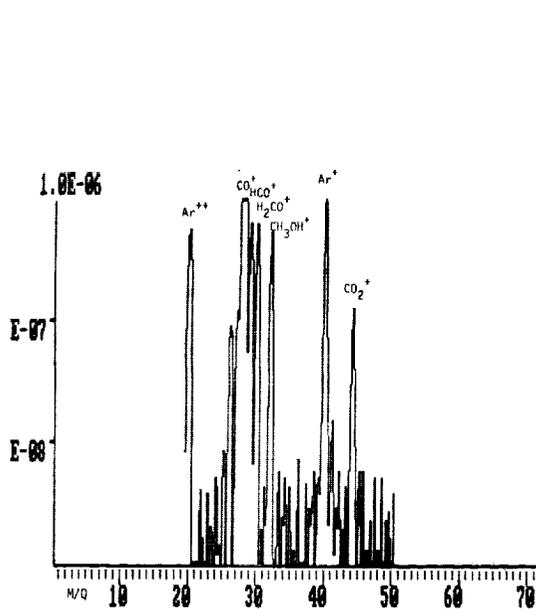


Fig 1. Mass spectrum of species ejected from a CO, Ar, and water ice during ion bombardment.

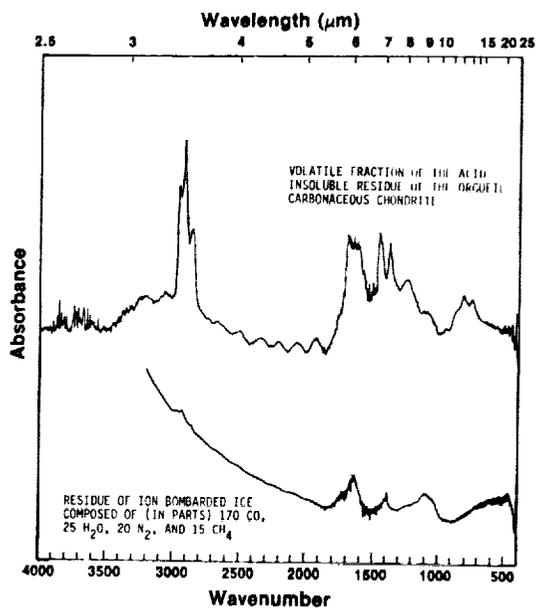


Fig 2. Infrared spectra of residue of ion bombarded ice and volatile fraction of the acid insoluble residue of the Orgueil meteorite.